

**NIST MRA Workshop 2005
Gaithersburg, MD U.S.A.**



EMR - SAR Testing & Approval Requirements for Australia



**Chris Zombolas, Technical Director
EMC Technologies, Melbourne, Australia**

chris@emctech.com.au



Topics Covered

- Human Exposure regulations- EMR Framework
- ARPANSA and ACMA EMR standards
- SAR Limits and Reference Levels
- EMR Compliance – Four measurement methods
- SAR Compliance – Two Measurement Methods
- When to test for SAR
- Labelling requirements, which mark?
- Compliance records, accredited testing.
- Overview of SAR measurement methodology
- SAR Case histories, various products.
- IEEE 802.11a/b/g WLAN and laptop/portable devices

EMR Framework

- **The Radiocommunications (Electromagnetic Radiation (EMR) -Human Exposure) Standard 2003**
 - “Standard” sets limits for human exposure to EMR from specified mobile/portable Radiocommunications Transmitters
 - Created by Australian Communications Authority
 - Specifies ARPANSA (ICNIRP) Limits
 - Defines 3 SAR test methods



EMR Framework

- **The Radiocommunications (Compliance Labelling-Electromagnetic Radiation) Notice 2003 (Labeling notice)**
 - Register with ACA to use compliance mark
 - record keeping, supporting documentation
 - Testing and report requirements
 - Laboratory accreditation
 - Compliance levels
 - Labelling requirements
 - Declaration of Conformity (DoC)



Background - Electromagnetic Radiation (EMR)

- Radiocommunications transmitters emit radio frequency electromagnetic radiation (RF EMR)
- Use of RF devices widespread
 - Public concern over possible health effects
 - Rapid Proliferation of RF transmitters
- Regulations set human exposure limits
- ACA makes standards to protect health & safety of users of these devices



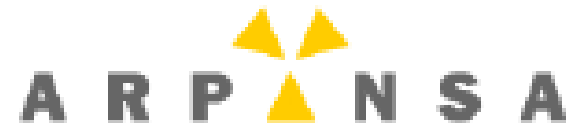
ACA Timeline for EMR Framework

- **1997** public discussion paper
- **1999** Mandatory limits for human exposure
 - Radiocommunications (EMR-Human Exposure) Standard 1999. Under section 162 of Act
- **2000** Standard amended to include more devices used at the ear 800 MHz to 2500 MHz
- **1 Jan 2002** EMR standard
 - intended for all devices 3 kHz–300 GHz with integral antenna
 - Legal problems
- **2003 EMR Standard 2003 mandated 1st March**
 - Covers all devices, integral antenna,
 - SAR up to 20cm from body, field measurements >20cm
 - ARPANSA Std has criteria for SAR evaluation

ICNIRP Guidelines for Human Exposure to RF fields



- International Commission on Non-Ionizing Radiation Protection (ICNIRP)
- Guidelines Published April 1998,
- Adopted by ARPANSA Std 2002

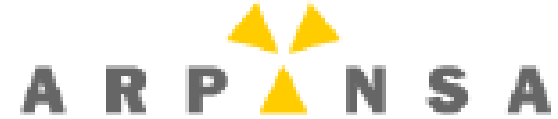


ARPANSA Radiation Protection Standard



Australian Government

Australian Radiation Protection
and Nuclear Safety Agency



- “**A**ustralian **R**adiation **P**rotection **A**nd **N**uclear **S**afety **A**gency (**ARPANSA**) - Maximum exposure levels to Radio Frequency fields, 3 kHz to 300 GHz”
- Replaced AS/NZS 2772.1 (interim)1998
- Sets basic restrictions and reference levels
- Sets SAR limits and specifies criteria for SAR evaluation
- SAR measurement methods not given
- AS/NZS2772.2 specifies field measurement and calculation methods, not SAR



RADIATION PROTECTION STANDARD

Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz



RADIATION PROTECTION SERIES No. 3

Available from website
www.arpansa.gov.au

ARPANSA Radiation Protection Standard

- **Scope**
 - SAR limits / derived field levels of part or all of the human body to RF fields (3 kHz - 300 GHz)
 - Whole body average and peak spatial SAR limits for occupational and non occupational exposure (includes corresponding E, H and S levels)
 - Equipment and usage parameters to readily determine compliance

Exposure Limits

- **RF/microwave safety standards consist of:**
 - **Basic restrictions** (exclusions), i.e. **SAR**
 - **Reference Levels** or Maximum Permissible Exposure (**MPE**) values, e.g. incident electric (**E**) or magnetic (**H**) field strength, power density. Easier to measure.
 - sometimes called **‘investigation levels’**

Basic Restrictions

Specific Absorption Rate (SAR) limited to;

	Controlled / Occupational	Uncontrolled / General Public
Whole Body Averaged SAR	0.4 W/kg	0.08 W/kg
Spatial peak -Head & Torso	10 W/kg	2 W/kg
Spatial peak -Limbs	20 W/kg	4 W/kg

SAR measured in a 10 gram cube of tissue
www.emctech.com.au

Spatial Peak SAR

Partial-body exposures to low power devices may easily meet the whole-body-averaged SAR limits but the local fields may exceed the maximum Reference Levels close to the source,

e.g. portable devices

- wireless handsets
- mobile phones
- laptop PC with WLAN
- Wireless PDA

SAR: What is it?

SAR is related to the electric field at a point by

$$\text{SAR} = \frac{\sigma |E|^2}{\rho}$$

Where

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m³)

E = rms electric field strength (V/m)

Note: SAR is only valid over the frequency range of ~ 100 kHz – 6 GHz

Reference Levels

- Definition; *“Practical or ‘surrogate’ parameters that may be used for determining compliance with the basic restrictions.”*
- Exposure to fields less than the reference levels which are derived from dosimetric modelling and experiments, ensures that the resulting SAR will not exceed the basic restrictions (SAR)
- Measurement of the incident fields is relatively straight-forward – measurements of SAR is not

ARPANSA Reference Levels For Time Averaged Exposure To RMS Electric And Magnetic Fields (Unperturbed Fields)

Exposure category	Frequency range	E-field strength (V/m rms)	H-field strength (A/m rms)	Equivalent plane wave power flux density S_{eq} (W/m ²)
Occupational	100 kHz – 1 MHz	614	$1.63 / f$	-
	1 MHz – 10 MHz	$614 / f$	$1.63 / f$	$1000 / f^2$ (see note 5)
	10 MHz – 400 MHz	61.4	0.163	10 (see note 5)
	400 MHz – 2 GHz	$3.07 \times f^{0.5}$	$0.00814 \times f^{0.5}$	$f / 40$
	2 GHz – 300 GHz	137	0.364	50
General public	100 kHz – 150 kHz	86.8	4.86	-
	150 kHz - 1 MHz	86.8	$0.729 / f$	-
	1 MHz - 10 MHz	$86.8 / f^{0.5}$	$0.729 / f$	-
	10 MHz – 400 MHz	27.4	0.0729	2 (see note 6)
	400 MHz – 2 GHz	$1.37 \times f^{0.5}$	$0.00364 \times f^{0.5}$	$f / 200$
	2 GHz – 300 GHz	61.4	0.163	10

ARPANSA E Field Reference Levels

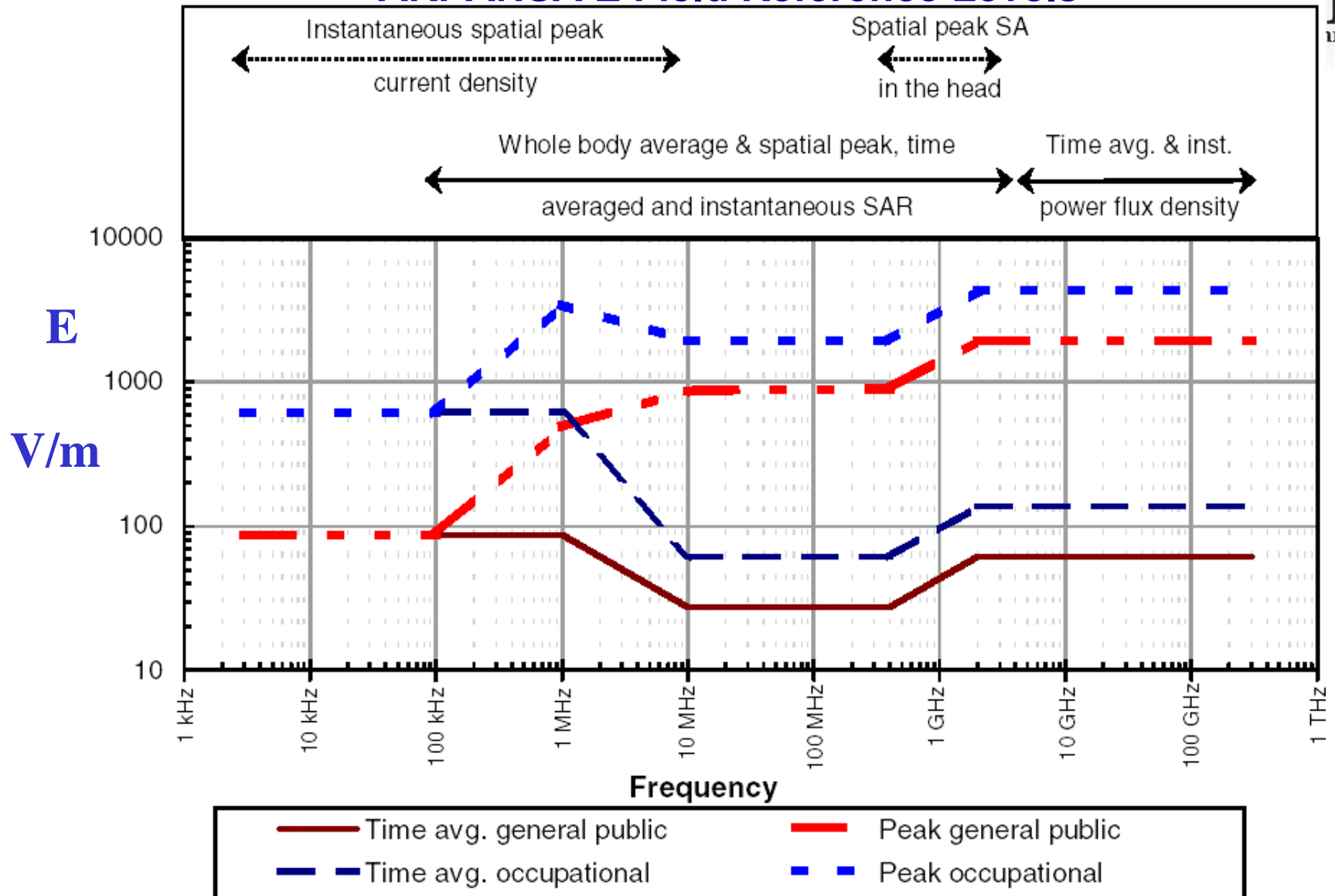


Figure 1 Reference levels for instantaneous and time averaged rms exposure to electric fields (refer Tables 7 & 8 and look-up tables in Schedules 2 and 3).

ACMA Reference Levels – Limits:

Non-occup/General Public/Unaware Users

Frequency Range (MHz)	Electrical Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (Wm ²)	Averaging Time (E ²), (H ²) or (S) (minutes)
0.3 – 1.0	6.8	0.729/f		6
1-10	6.8/f ^{0.5}	0.729/f	--	6
10 - 400	27.4	0.0729	2	6
400-2000	1.37xf ^{0.5}	0.00364xf ^{0.5}	f/200	6
2000 - 100,000	61.4	0.163	10	6

SAR Limits - Occupational

	Australia	USA	Europe (ICNIRP)	Japan	New Zealand
	ACA	ANSIC95.1	EN50360	TTC/MPT	NZS2772.1
Whole Body	0.4 W/kg	0.4 W/kg	0.4 W/kg	0.4 W/kg	0.4 W/kg
Spatial Peak	8 W/kg	8 W/kg	10 W/kg	8 W/kg	10 W/kg
Averaging Time	6 min	6 min	6 min	6 min	6 min
Averaging Time	1g	1g	10g	10g	10g
Shape	Cube	Cube	Cube	Cube	Cube

Comparison of SAR Limits Non-occupational/General Public

	Australia ARPANSA	USA	Europe (ICNIRP)	Japan	New Zealand
	ACA	ANSI C95.1	EN50360	ARIB- T56	NZS2772.1
Whole Body	0.08 W/kg	0.08 W/kg	0.08 W/kg	0.08W/kg	0.08 W/kg
Spatial Peak	2 W/kg	1.6 W/kg	2 W/kg	2 W/kg	2 W/kg
Averaging Time	6 min	30 min	6 min	6 min	6 min
Averaging Time	10g	1g	10g	10g	10g
Shape	Cube	Cube	Cube	Cube	Cube

Definitions

- **Occupational Exposure**
 - Exposure under controlled conditions
 - Persons trained or informed to be aware of potential risks and take appropriate precautions
 - Duration limited to duration of working day
 - Excludes pregnant workers, who must not exceed non occupational limit

Definitions

- **Non Occupational Exposure**
 - Exposure to persons, other than in the course of or intrinsic to their work
 - Persons of all ages and health status
 - Includes pregnant workers, who would normally be occupationally exposed but who have informed their employer of their pregnancy

EMR Standard 2003 Compliance

Four Common Methods

1. Non-evaluation criteria (low power etc)
2. SAR Measurements
3. Reference Level Measurements
 - E-field
 - H - Field
 - Power Density
 - Limb/Contact Currents
4. Modelling/Predictions with manual or computer calculations

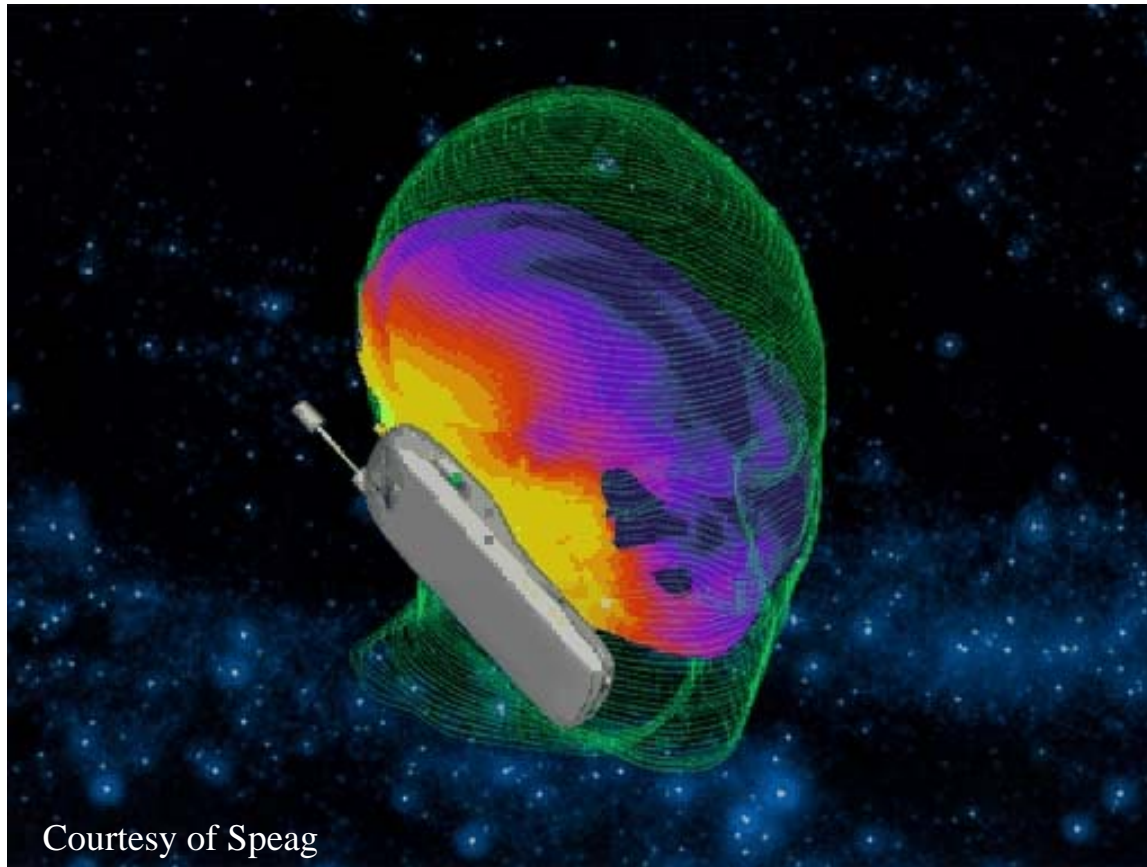
ACA EMR Standard 2003

Assessment Methods for Devices Exceeding Power Threshold

User Position	Applicable Frequency Range	ACA Evaluation Method
> 20 cm from Human Body	300 kHz to 100 GHz	Power density or Field Strength Reference Level measurements - EMR Meter AS2772.2
< 20 cm from Human Body	150 MHz – 5800 MHz	SAR measurements Push-to-Talk / Body Worn devices – -SAR per Schedule 2
Close Proximity to Human Ear	300 MHz – 3000 MHz	SAR Measurements at the ear Mobile/Portable Phones - -SAR per Schedule 2 or EN50361
< 2.5 cm from Human Body	300 kHz-100 GHz	If less than 20 mW, - complies without testing



ACA SAR Measurement Standards



Courtesy of Speag



Two SAR Measurement Methods

ACMA Scope for SAR test:

**SAR evaluation for devices with integral antenna
and 150 MHz to 5.8 GHz**

- 1. Schedule 1; Old ACA SAR test method, expired March 2005**
- 2. EN50361; CENELEC**
- 3. ACMA Schedule 2; Similar to FCC OET65C 01-01**
- 4. EMR Meter Power density/Reference Level measurement**

EMR- SAR Measurements

**Level 3 test
For SAR compliance**



**Level 2 test
Field Strength Meter**



SAR Measurement System



2 ACA SAR Test Methods

- **Schedule 1 (Old ACA Method) Expired March 2005**

Specific Absorption Rate Test Method Using Phantom Model of the Human Head (1): 2001

- Devices used near the head
- 800 MHz to 2500MHz
- Early SAR standard
 - Defined SAR equipment, specifications, report requirements
 - Choice of Phantom
 - Brain Tissue Dielectric parameters, OLD FCC values (lower)
 - Less conservative SAR result, easier to comply

2 ACA SAR Test Methods (1)

- **EN50361** CENELEC Basic Standard
 - 300 MHz to 3 GHz
 - Devices used at the ear
 - Best for mobile phones (cell phones), cordless phones
 - Very similar to IEEE 1528
 - SAM Phantom, dielectric parameters
 - SAR scanning
 - SAR probes

2 ACA SAR Test Methods (2)

- **Schedule 2:**

“Measurement method for devices 20cm or less from the human body

Part 1: Information for documenting SAR compliance

Part 2: Tissue Dielectric parameters

Part 3: SAR Measurement Procedures”

- 150 MHz to 5.8 GHz
- 20 cm or less from the body
 - Body worn/PTT devices, WLAN Laptop, PDAs etc
- Very similar to FCC *OET65C 01-01*
 - *Specific reporting requirements*
 - *Head and Body Phantoms defined*
 - *Procedures, verification, uncertainty, EUT configuration*

Reference Level Measurements

- Devices **>20 cm** from human body
- 300 kHz to 100 GHz
- Field Measurements per AS 2772.2
- Must comply with Reference Levels (MPE)
- Conventional RADHAZ field/power density meter used
- Relatively simple compared to SAR test, much cheaper

What Needs Testing?



Compliance of Mobile Stations

- Mobile / portable transmitting equipment may be designed to be used close to the human body.
- Results in illumination of a small portion of the user's body
 - produces fields with a highly non-uniform spatial distribution.
- Compliance determined from a consideration of equipment parameters and conditions of use
- **Table S1 and S2 ARPANSA standard sets evaluation and non-evaluation criteria**

SUMMARY OF COMPLIANCE PROVISIONS FOR MOBILE OR PORTABLE TRANSMITTING EQUIPMENT

ARPANSA

Table S1

Equipment parameters	Test exemption	Spatial peak SAR [Table 2 Occupational]	Spatial peak SAR [Table 2 General Public]	Field measurement [Tables 7 & 8 Occupational or evaluation using S5.2.3]	Field measurement [Tables 7 & 8 General Public or evaluation using S5.3.3]
Aware user exposure					
Mean power < 100 mW	✓				
Push-to-talk & mean power < Table S2 & duty factor < 50 % & separation > 2.5 cm	✓				
Mean power > Table S2 & separation > 20 cm				✓	
Otherwise		✓			
General public exposure					
Mean power < 20 mW	✓				
Push-to-talk & mean power < 1/5 of Table S2 & duty factor < 50 % & separation > 2.5 cm	✓				
Mean power < Table S2 & separation > 20 cm	✓				
Mean power > Table S2 & separation > 20 cm					✓
Otherwise			✓		

Evaluation or non-evaluation criteria

Test Exemption - Aware Users

- Equipment with mean power delivered to antenna
< 100 mW
- Evaluation of equipment **not required**
Complies without testing.

Test Exemption - Non-aware Users

- Non-aware or General Public Users
- Equipment with mean power delivered to antenna **< 20 mW**
- Evaluation of equipment **not required**
Complies without testing

Table S1 ARPANSA

Threshold Levels for SAR Testing
Device < 2.5 cm from body

Frequency MHz	Aware User RF Worker	Unaware User General Public
0.1 – 2500	100 mW	20 mW

SAR Evaluation Required if;

1. average power exceeds threshold level, or
2. Operates between 2500 to 5800 MHz and within 20cm

Table S2 ARPANSA

Threshold Levels for SAR Testing
Device < 20 cm and >2.5cm from body

MPTE Operating Frequency f (MHz)	Aware User Clause S5.2 Mean Power Output - Watts	Non-Aware User Clause S5.3 Mean power output - Watts
0.1 - 450	7	1.4
450 - 2500	$3150/f$	$630/f$

**SAR evaluation required for frequency between
2500 and 5800 MHz and used within 20 cm**

The Radiocommunications (Compliance Labelling- Electromagnetic Radiation) Notice 2003

ACA EMR Labelling Notice



Labelling Requirements

- Labelling requirements same as for C-tick
 - Obtain Supplier ID
 - Prepare SAR test report (+other test reports)
 - Prepare Description of device
 - Prepare Compliance Folder
 - Declaration of Conformity
 - Apply A-tick
 - No need to report actual SAR in user information.

Compliance Level 1

- **Applies to Category A devices**
 - Determined by *Table S1 ARPANSA*
 - Low power and cannot exceed basic restrictions
 - E.g. analogue cordless phones, electronic garage door opener, (*some*) low power WLAN for PC
- **Requirements**
 - Deemed to comply without testing (but must still comply!)
 - Compliance labelling
 - Declaration of Conformity must be signed
 - Description of transmitter/device in compliance folder

Compliance Level 2

- **Applies to Category B devices**
 - Devices which are not Category A
 - Normally used >20cm from body
 - Power sufficient to exceed basic restrictions
 - Apply *Table S1 ARPANSA*
 - WLAN, Access Points, base station, mobile stations
- **Requirements**
 - Must comply with Reference Levels **E, H** or **Power Density**
 - Evaluation of device required per AS/NZS2772.2
 - Compliance mark required
 - Description of device
 - DoC

Compliance Level 3 – SAR Test

- **Applies to Category B devices <20cm from Body**
 - Devices which are not Category A
 - Normally used <20cm from body
 - Power sufficient to possibly exceed basic restrictions
 - Apply *Table S1 ARPANSA*
 - Cell-phones, portable handheld/body-worn devices, PTT WLAN, Access Points, base station, mobile stations
- **Requirements**
 - SAR Evaluation must be performed
 - NATA MRA accredited test lab (Level 3 compliance)
 - 2 SAR test methods per ACA EMR Standard 2003
 - Evaluation to ARPANSA human exposure limits
 - Records, Labelling, DoC

Laboratory Accreditation Requirements

- **Compliance Level 1 and 2**
 - accreditation not mandatory but preferred.
- **Compliance Level 3**
 - Must be accredited to conduct tests to ACA EMR Standard 2003 by **NATA**
or by
 - International body having Mutual Recognition Agreement (MRA) with **NATA**
e.g UKAS, NVLAP, A2LA,, DAR, etc
 - **Must be accredited to EN50361 +ACA Schedule 2**

Which Compliance Mark?

- Radiocommunications devices may be labelled with

- C-Tick



- Devices to which the **EMR & Telecoms** labelling apply require

- A-Tick



<http://www.aca.gov.au/standards/marks.htm>

Same as EMC Framework

www.emctech.com.au

Supplier Identification

- EMR labelling notice requires one of
 - C-Tick
 - A-Tick
- Compliance label to include
 - Compliance mark
 - Supplier Identification

Same as EMC Framework

Supplier Identification

- **Options for supplier identification are ...**
 - Business name & address in Australia
 - Business name registered on national business register
 - Personal name & address in Australia of the place of business
 - Australian company number (ACN)
 - Australian registered body number
 - Australian business number (ABN)
 - Australian registered trademark
 - Supplier code issued by ACA

Same as EMC Framework

Who May Apply Compliance Labels?

- **Products manufactured in Australia**
 - Australian manufacturer
 - Authorized agent
 - Person authorized by manufacture or agent
 - Copy of authorization to be kept with compliance records
- **Products manufactured in Overseas**
 - Importer
 - Authorized agent in Australia/NZ
 - Overseas manufacturer authorized by importer or agent
 - Copy of authorization to be kept with compliance records

Same as EMC Framework

Variants of Device

- Variants may be included on same DoC
- Technical justification must be in writing
- Must identify the variant
- Cosmetic changes can be presumed not to degrade the SAR
- Acceptable rationale for not testing variants

Variants of Device

SAR must be re-assessed when variant likely to increase SAR:

eg:

- Changes to geometry of phone
- Changes to types of material used in construction of phone, keyboard, displays etc
- The use of alternate batteries
- Any changes to the antenna including the fitting of so called radiation reduction devices or performance enhancement devices

Contents of Compliance Record

- Must be kept for 5 years from last date of sale of product
- Must be in English
- May be kept electronically
- Subject to audit by ACA

Same as EMC Framework

Contents of Compliance Record

Compliance Records must include:

- A signed DoC
- Agency agreement between a manufacturer/importer & Australian agent
- Description of device

Same as EMC Framework

Contents of Compliance Record

Category B Devices:

- Report of testing performed by an **accredited** laboratory showing compliance with ACA EMR Standard 2003
- Statement identifying the device and the variants of the device under the same DoC

Contents of Compliance Record cont.

Category B Devices:

- Statement describing differences between the variant and the device
- Provision of technical rationale for conformity of variant; and
- Evidence that the RF emission **(SAR)** characteristics of the variant are not likely to exceed those of basic device

Audit Provisions

- Audits may be conducted on a random basis
- Audits may be conducted due to a complaint
- Compliance Folder must be produced within 10 days of written request by ACA
- ACA may request 3 samples of product within 10 days for testing by NATA accredited laboratory

Same as EMC Framework

Overview

ACMA SAR Measurement Methodology



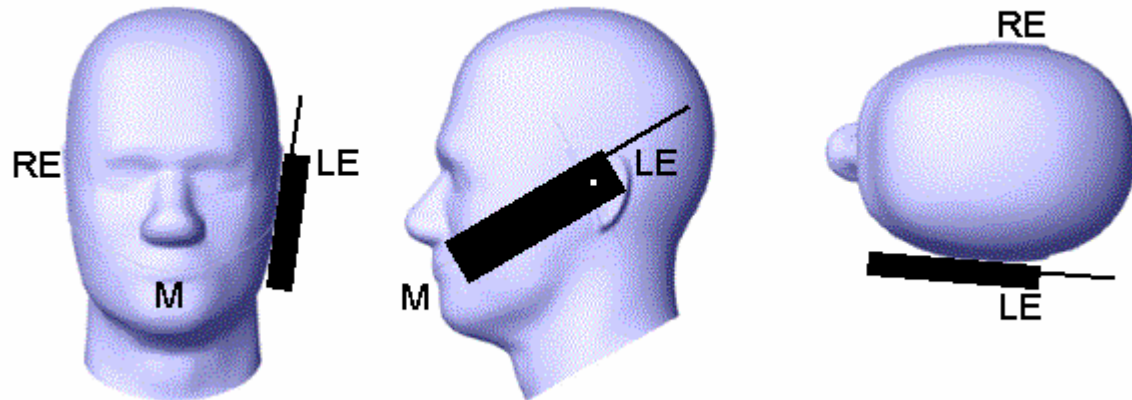
SAR Measurement Standards

- **EN 50361**
 - ACMA will adopt IEC 62209-1:2005
- ACA EMR Standard Schedule 1
 - Expired March 2005
- **ACA EMR Standard Schedule 2**
 - Adopted from FCC OET65C 01-01
 - Some minor variations
 - ACMA will adopt **IEC 62209-2** (when published)

Phone Test Positions

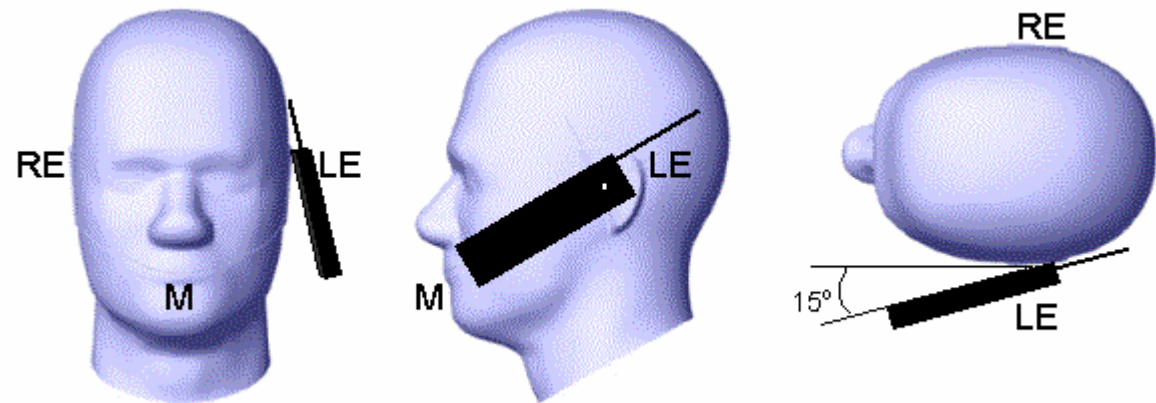
Touch Position

- Left Ear
- Right Ear



Tilt Position

- Left Ear
- Right Ear



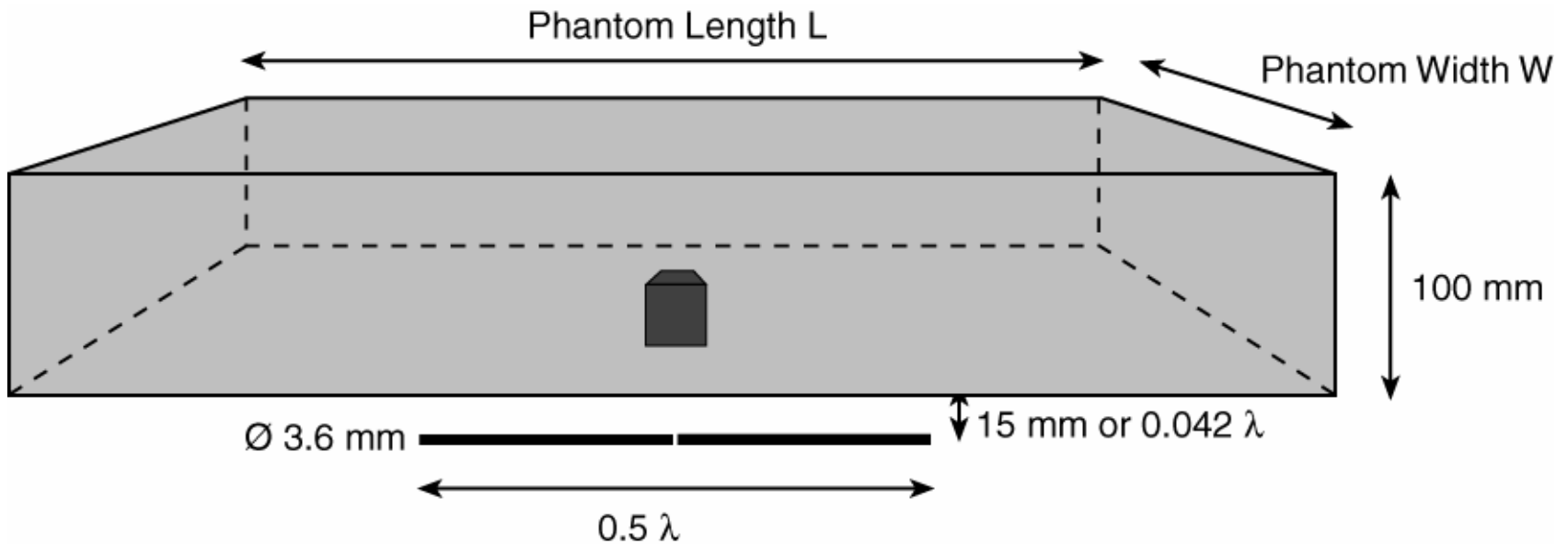
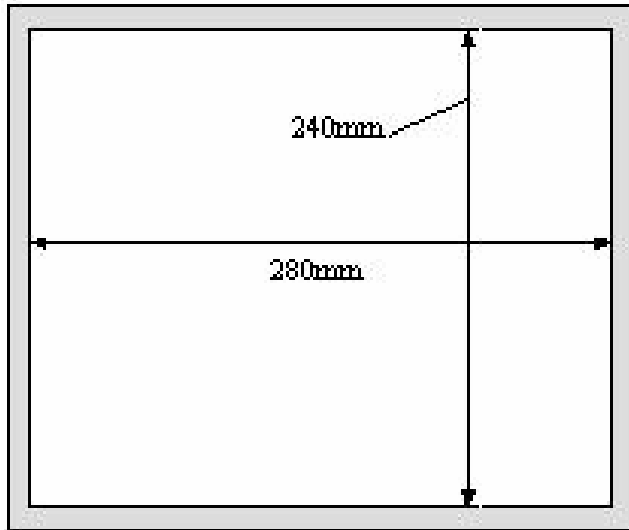
What About Devices Not Used at the Ear ?

No standardised method yet for SAR test on;

- Body worn device.**
 - Two way Radio
 - Laptop PC with WLAN
- Push to Talk (PTT) device**
- **FCC OET65C 01-01 has guidelines**
- **ACA Schedule 2 has adopted OET65C 01-01**
- **Flat Phantom (Box Phantom) is used**

Flat Phantom for

- Body worn Devices
- Face Position
- Hand held
- Laptop PC WLAN



Phantom must be twice as large as EUT

Flat Phantom

- Used with the recommended tissue equivalent material.
- Also for system performance checking and system validation purposes
- The minimum transverse dimensions for a half wavelength dipole source, length and width should be at least **0.6λ**
- **$\epsilon < 5$** and **$\tan \delta < 0.05$**
- **2 mm** thick (800 MHz – 6 GHz)
- **< 6.5 mm** thick (< 800 MHz)
- Liquid depth **15cm** minimum

Tissue Simulants

- Dielectric Constant ϵ_r
- Conductivity (siemens/m) σ

Measured at operating frequency

Frequency Band	EN50361 (head only)		ACA Schedule 2 (FCC OET 65C)			
			Head		Body/Muscle	
MHz	ϵ_r	σ	ϵ_r	σ	ϵ_r	σ
	±5%	± 5%	±5%	±5%	±5%	±5%
150			52.3	0.76	61.9	0.80
300	45.0	0.85	45.3	0.87	58.2	0.92
450	44.0	0.88	43.5	0.87	56.7	0.94
800	-	-	-	-	-	-
835			41.5	0.90	55.0	0.97
900	42.0	0.99	41.5	0.97	55.0	1.05
915			41.5	0.98	55.6	1.06
1430	41.0	1.3	40.5	1.20	54.0	1.30
1600						
1610			40.3	1.29	53.8	1.40
1800	40.0	1.38	40.0	1.40	53.3	1.52
2000			40.0	1.40	53.5	1.52
2450	39.0	1.84	39.2	1.80	52.7	1.95
2500						
3000	39.0	2.40	38.5	2.40	52.0	2.73
5800	??	??	35.3	5.27	48.2	6.00

Comparison of Tissue Dielectric Values

20-26 deg C
±2 deg C

Harmonized??

Uncertainty Analysis

Near-Field Measurement and Scanning Technology

Combined Uncertainties (Summary)

Error Description	Standard Uncertainty	Offset
E-field probe errors	$\pm 6.9\%$	
SAR evaluation error	$\pm 7.4\%$	+5%
Source uncertainty	$\pm 6.7\%$	
Combined Standard Uncertainty:	$\pm 12.1\%$	
Expanded Uncertainty (k=2)	$\pm 24.2\%$	

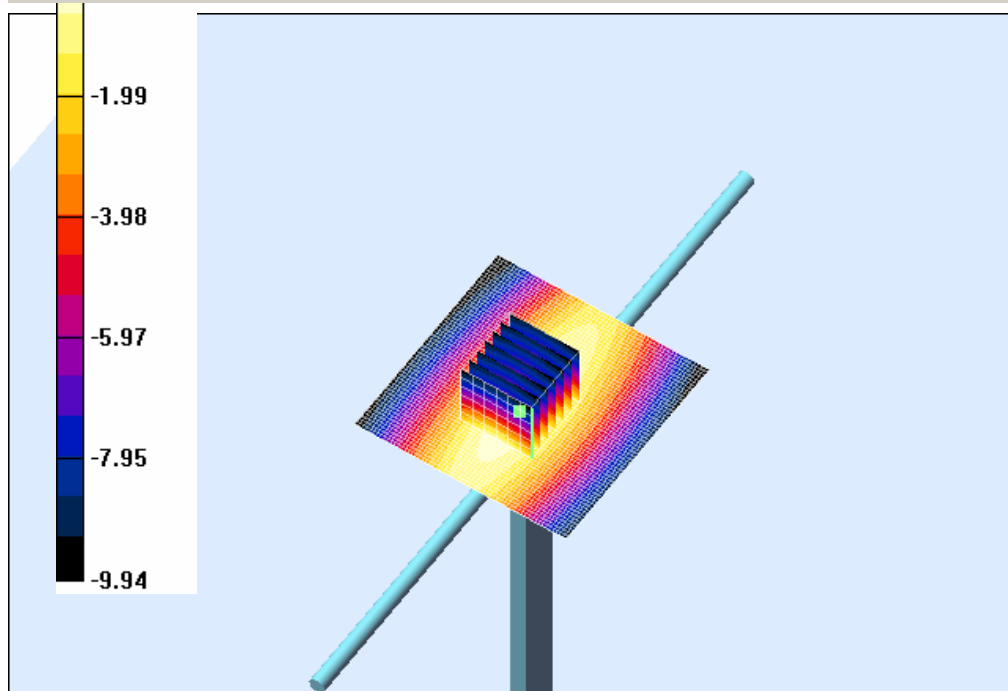
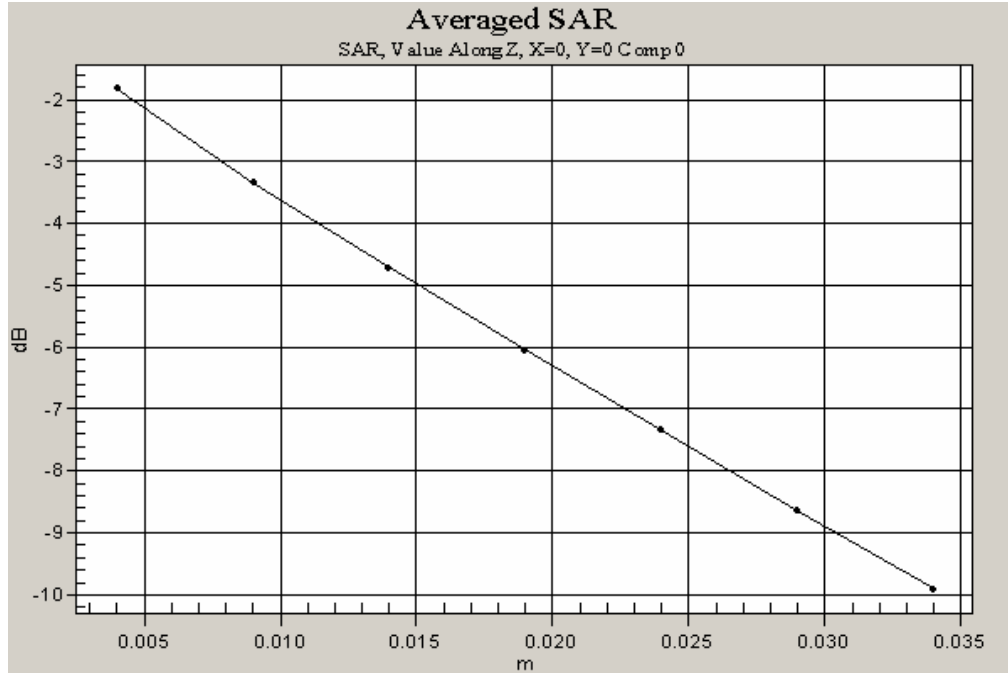
$\pm 24\% \equiv \pm 0.9 \text{ dB} \quad !!!$



Phone Positioning



**High level of precision
and repeatability
required**



SAR Scan Z-Axis

**System Check using
Standard;**

- dipole**
- dielectric tissue**
- flat phantom**

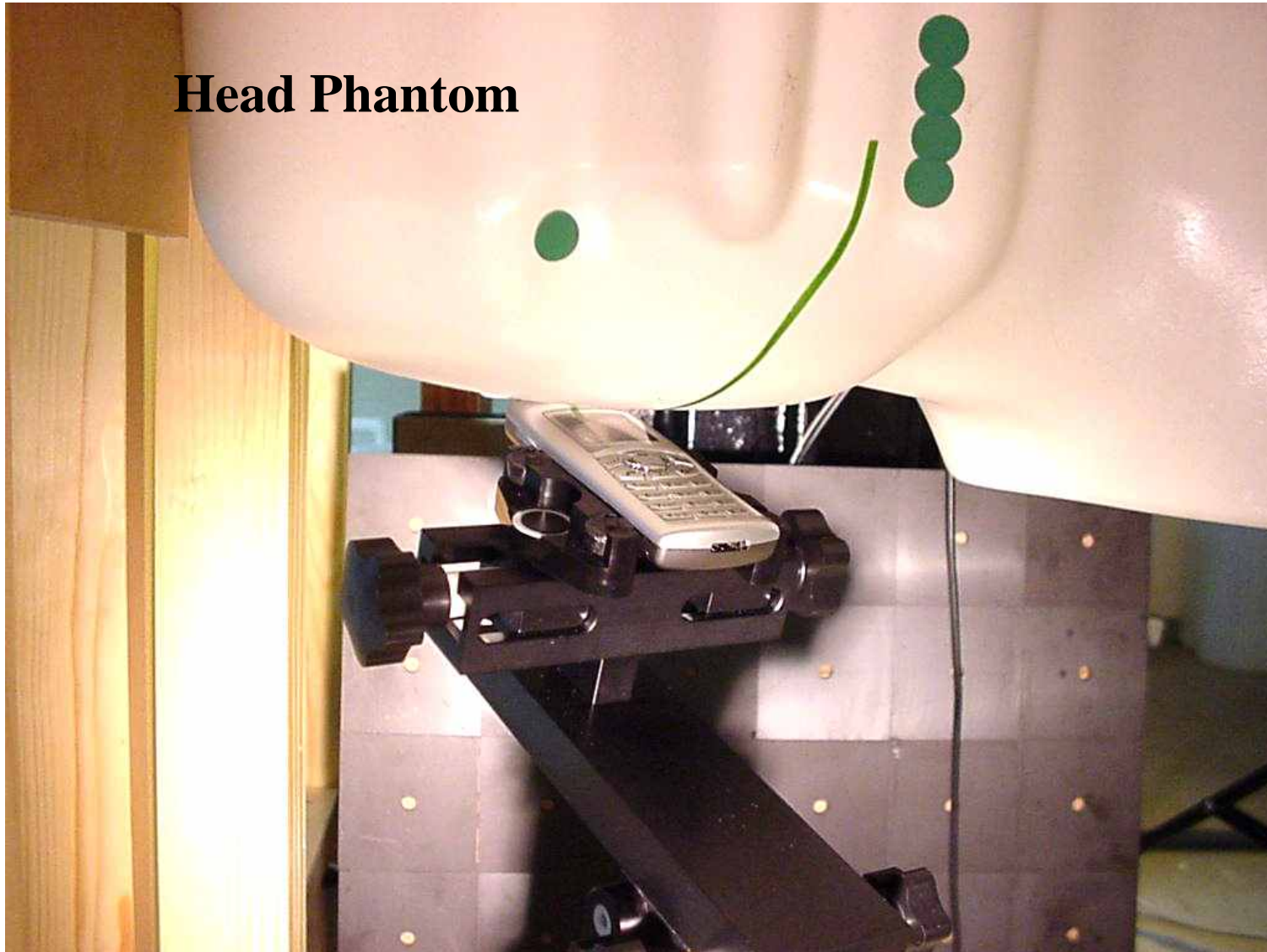
**Detects measurement
System problems**

SAR Tests

Case Histories

SAR Measurements

Head Phantom



Channel 001Test/Area Scan (101x61x1): Measurement grid: dx=15mm, dy=15mm

Reference Value = 33.9 V/m

Power Drift = -0.1 dB

Maximum value of SAR = 1.25 mW/g

Channel 001Test/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

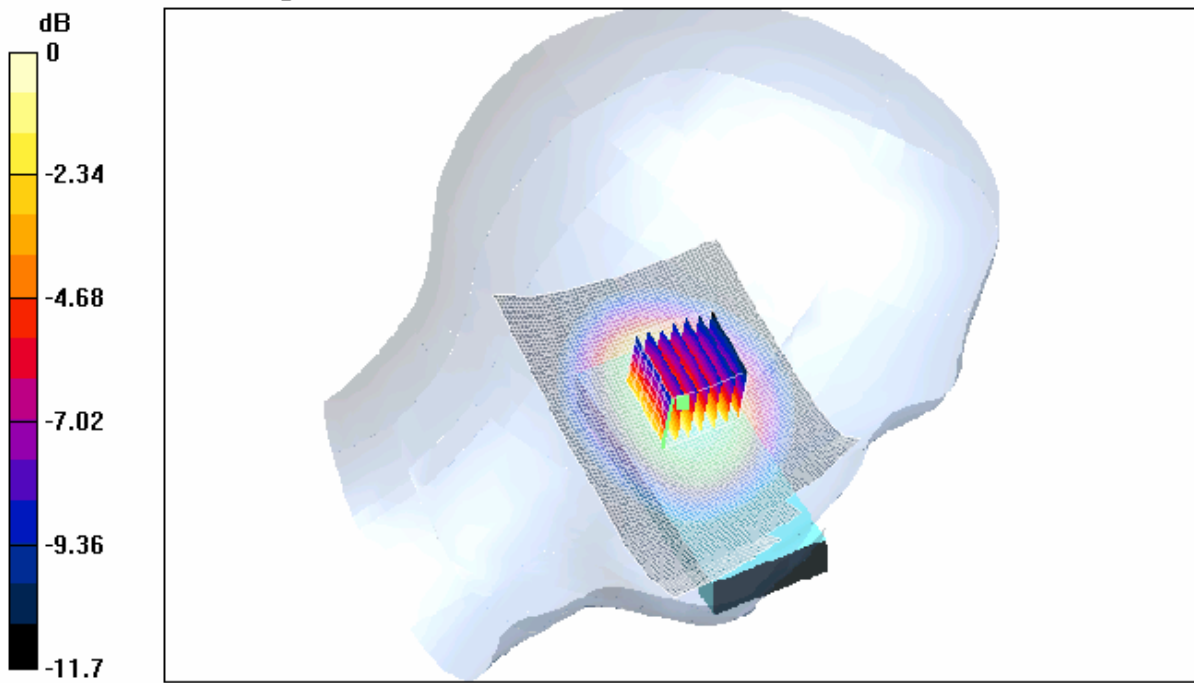
Peak SAR (extrapolated) = 1.69 W/kg

$$\text{SAR}(1\text{ g}) = 1.23\text{ mW/g}; \text{SAR}(10\text{ g}) = 0.831\text{ mW/g}$$

Reference Value = 33.9 V/m

Power Drift = -0.1 dB

Maximum value of SAR = 1.3 mW/g


$$0 \text{ dB} = 1.3 \text{ mW/g}$$

SAR MEASUREMENT PLOT

Ambient Temperature

19.4 Degrees Celsius

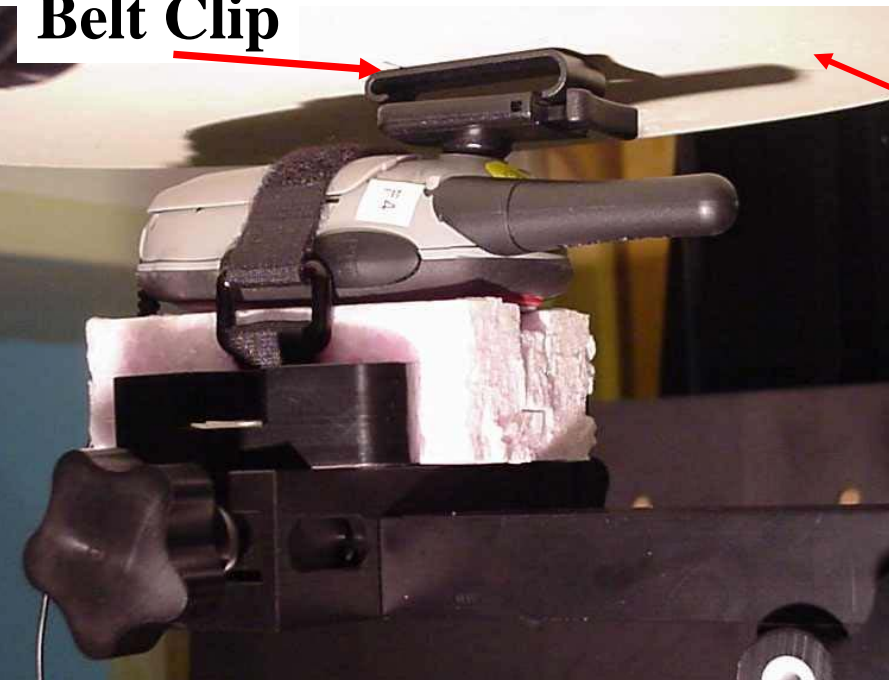
Liquid Temperature

19.1 Degrees Celsius

Humidity

39 %

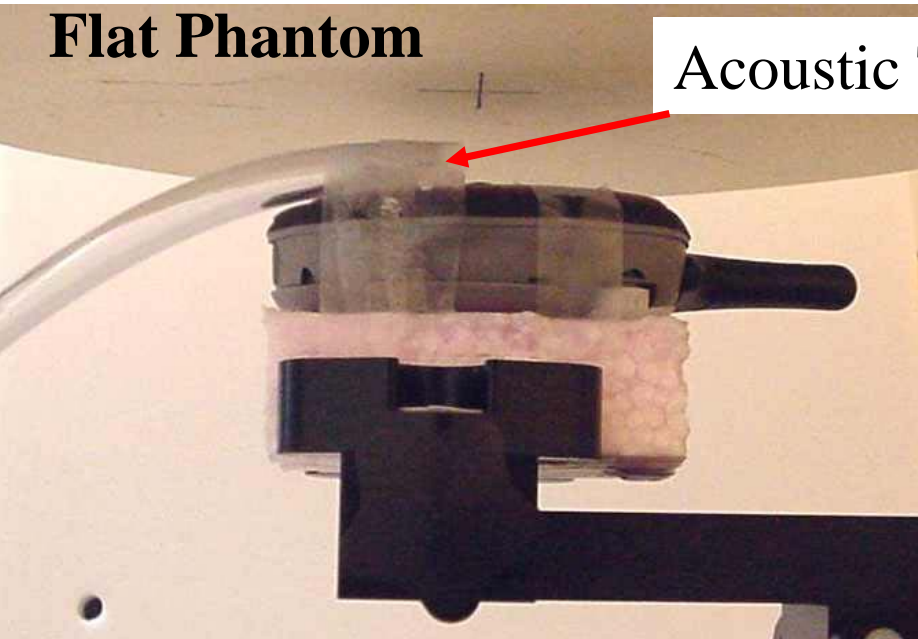
Belt Clip



Flat phantom

Sound Activated PTT Device –Auto STBY

Flat Phantom



Acoustic Tube



PTT Body Worn Device

Channel 11 Test/Area Scan (51x71x1): Measurement grid: $dx=20\text{mm}$, $dy=20\text{mm}$

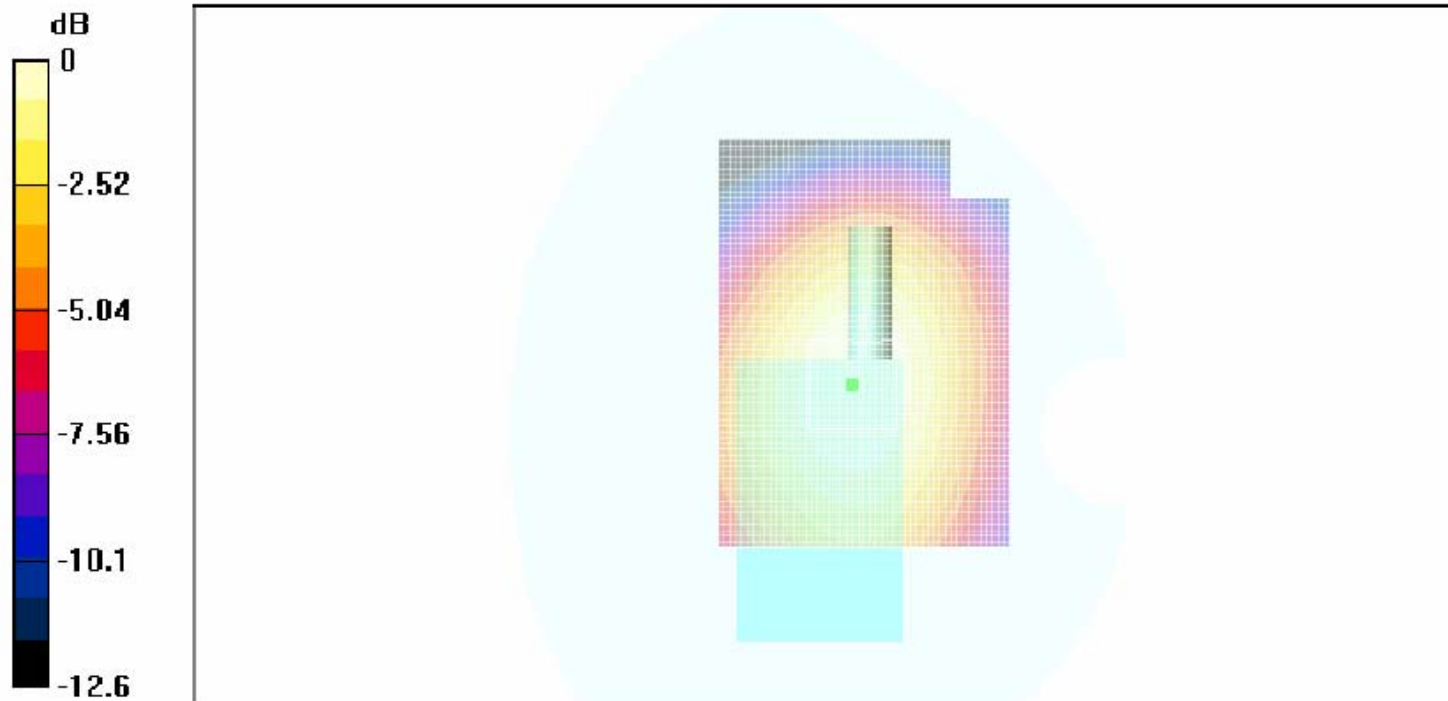
Channel 11 Test/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 22.4 V/m

Peak SAR = 1.22 W/kg

SAR(1 g) = 0.845 mW/g ; SAR(10 g) = 0.606 mW/g

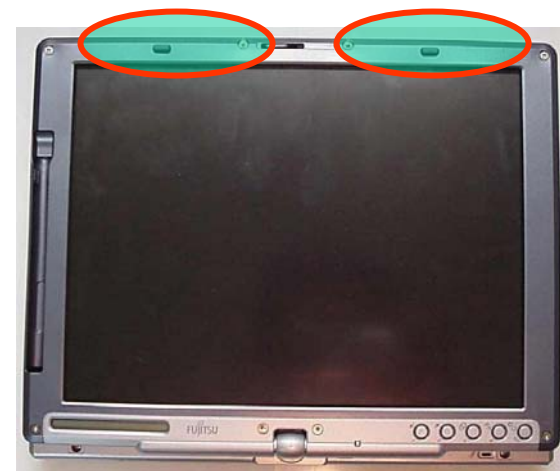
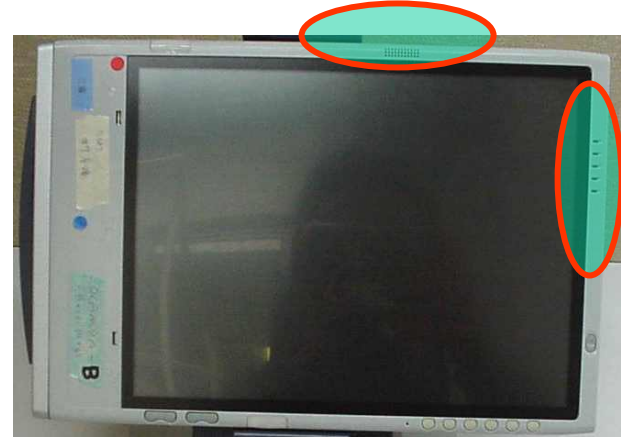
Power Drift = 0.3 dB



Compliance Testing of Laptop and Tablet Portable computer in Australia

- Currently general procedures are prescribed in Schedule 2 of ACA EMR Standard.
- Test positions generally correspond to the locations of antennas. Bottom? Front? On the lid? Can the WLAN module operate with lid closed?

Typical Location of Antenna's on Different Portable Equipment



Compliance Testing of Laptop and Tablet Portable computer in Australia

(2)

- Used in a typical ‘laptop’ position and the antenna is located along the front of the laptop then exposure would occur at less than 20cm from the stomach or groin.
- Referring to ARPANSA standard at 2500MHz the threshold mean output power = 20mW for <2.5cm.

Compliance Testing of Laptop and Tablet Portable computer in Australia

(3)

- This exemption holds true if the manufacturer can prove that it is not possible for normal use of device within 20cm of the body.
 - Simple power density measurement applies
- If device is used closer than 20cm to body then only option is to carry out SAR test (output power dependant).

SAR scan- front of Screen



SAR Plot - Laptop Position

Program: LapTop Position

Communication System: DSSS 2450 MHz; Frequency: 2462 MHz; Duty Cycle: 1:2.2

Medium: Body 2450 MHz; ($\sigma = 2.048$ mho/m, $\epsilon_r = 51.5594$, $\rho = 1000$ kg/m³)

Phantom section: Flat 2.2 Section

Dasy Configuration:

-Probe: ET3DV6 - SN1380; ConvF(4.5, 4.5, 4.5); Calibrated: 9/11/2002

-Sensor-Surface: 10mm (Mechanical Surface Detection)

-Electronics: DAE3 Sn442; Calibrated: 23/10/2002

-Phantom: Flat Phantom 9.1; Serial: P 9.1

-Measurement SW: DASY4, V4.1 Build 33; Postprocessing SW: SEMCAD, V1.6 Build 109

Channel 11 Test/Area Scan (71x71x1): Measurement grid: dx=15mm, dy=15mm

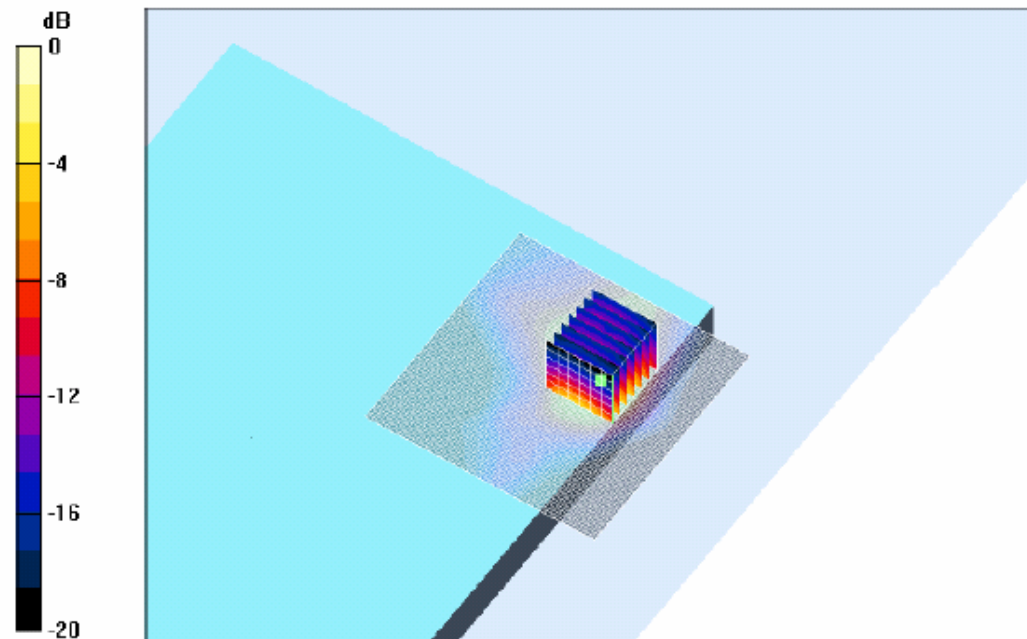
Channel 11 Test/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0.463 V/m

Peak SAR = 1.01 W/kg

SAR(1 g) = 0.511 mW/g; SAR(10 g) = 0.235 mW/g

Power Drift = 0.2 dB



Portable Wireless EFTPOS





**Portable EFTPOS
Terminal**



Body Phantom

Channel 885 Test/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Peak SAR (extrapolated) = 0.456 W/kg

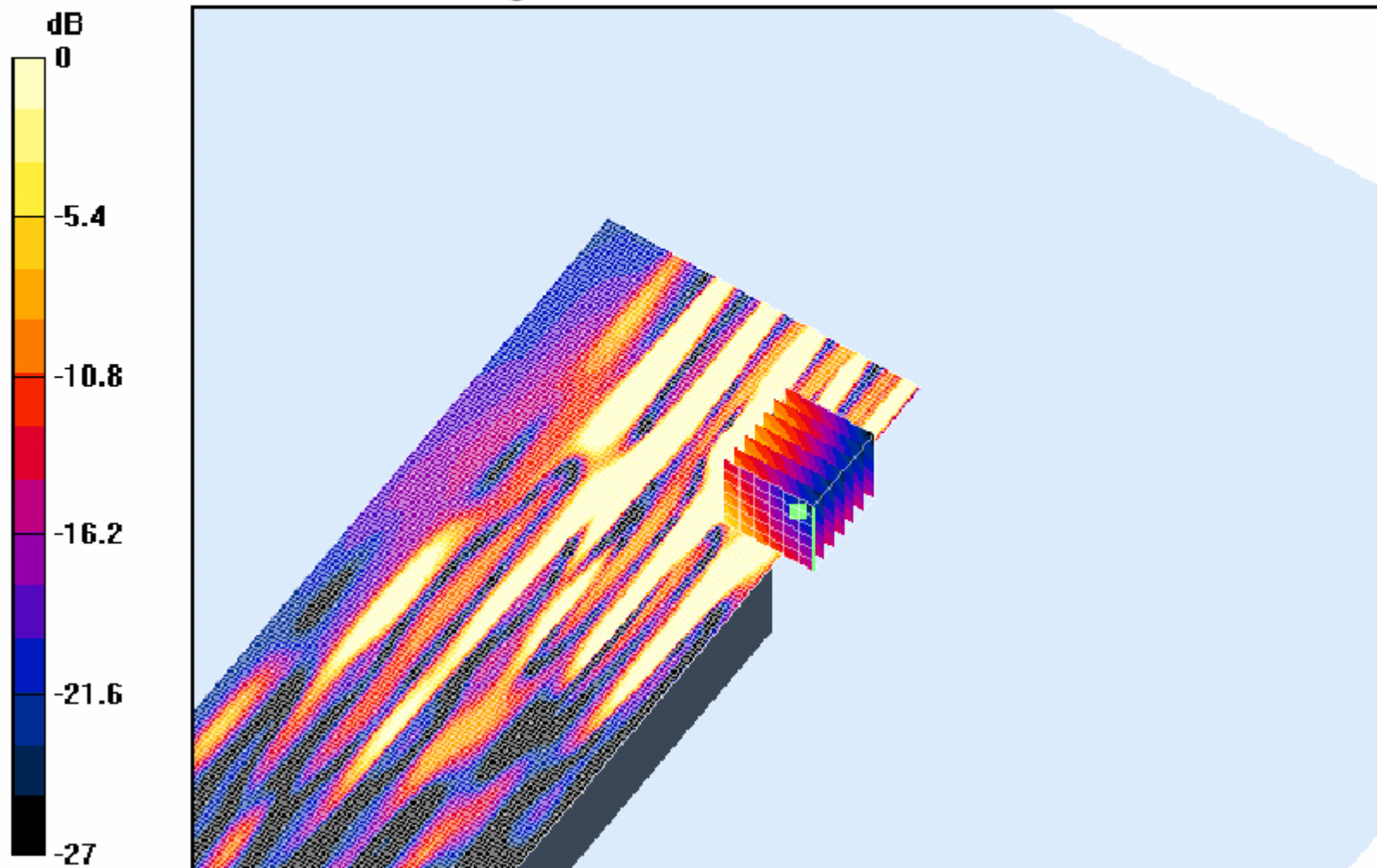
SAR(1 g) = 0.175 mW/g; SAR(10 g) = 0.07 mW/g

Reference Value = 2.61 V/m

Power Drift = 0.05 dB

Maximum value of SAR = 0.339 mW/g

Portable EFTPOS Terminal



0 dB = 0.339mW/g

SAR MEASUREMENT PLOT



350 MHz Head worn Transmitter

Steel Helmet

www.emctech.com.au

Head Worn Transmitter Fitted to “SAM”

Metal Foil (shielded??) Helmet



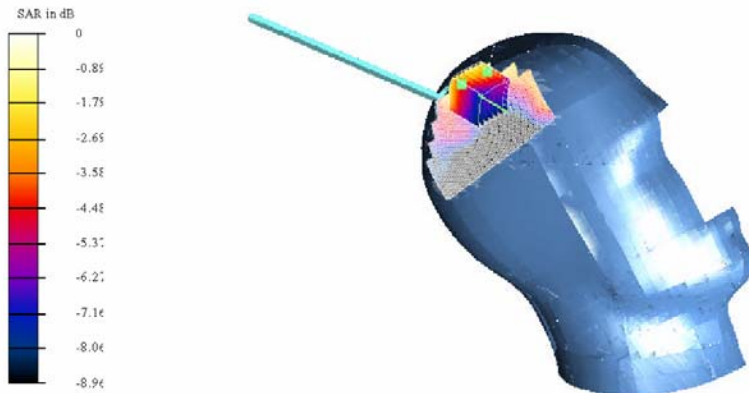
Test Laboratory: EMC Technologies Pty Ltd
File Name: M030230 - Osmar - Touch Left - 18-03-03.da4

DUT: Osmar Player Unit S/N: Demo-40268
Program: Touch Left Position; Channel 2 Test 2

Communication System: Pulsed 350 MHz; Frequency: 348 MHz; Duty Cycle: 1:20
Medium: FCC 350MHz ($\sigma = 0.90858 \text{ mho/m}$, $\epsilon = 44.2223$, $\rho = 1000 \text{ kg/m}^3$)
Phantom section: LeftSection

DASY4 Configuration:
- Probe: ET3DV6 - SN1377; ConvF(7.4, 7.4, 7.4); Calibrated: 6/09/2002
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn442; Calibrated: 23/10/2002
- Phantom: SAM 12 - TP: 1060
- Software: DASY4, V4.0 Build 51

Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$
Reference Value = 3.77 V/m
Peak SAR = 0.391 mW/g
SAR(1 g) = 0.141 mW/g; SAR(10 g) = 0.0939 mW/g
Power Drift = -0.04 dB
Area Scan (251x121x1): Measurement grid: $dx=10\text{mm}$, $dy=10\text{mm}$



Without metal helmet

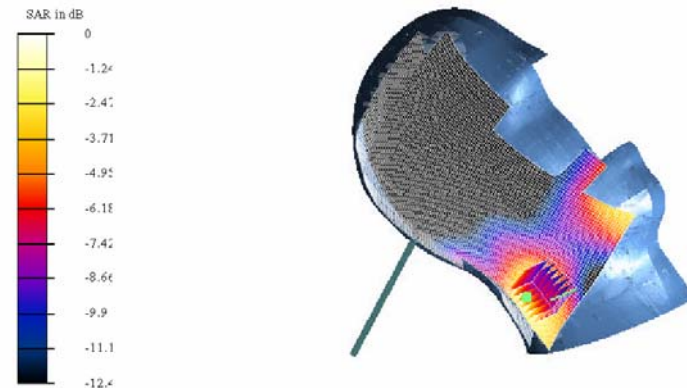
Test Laboratory: EMC Technologies Pty Ltd
File Name: M030230 - Osmar - Touch Left - 19-03-03.da4

DUT: Osmar Player Unit ; S/N: Demo-40268
Program: Touch Left Position; Channel 1 Test Helmet Worn

Communication System: Pulsed 350 MHz; Frequency: 336 MHz; Duty Cycle: 1:20
Medium: FCC 350MHz ($\sigma = 0.83 \text{ mho/m}$, $\epsilon = 44.347$, $\rho = 1000 \text{ kg/m}^3$)
Phantom section: LeftSection

DASY4 Configuration:
- Probe: ET3DV6 - SN1377; ConvF(7.4, 7.4, 7.4); Calibrated: 6/09/2002
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn442; Calibrated: 23/10/2002
- Phantom: SAM 12 - TP: 1060
- Software: DASY4, V4.0 Build 51

Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$
Reference Value = 2.72 V/m
Peak SAR = 0.635 mW/g
SAR(1 g) = 0.238 mW/g; SAR(10 g) = 0.134 mW/g
Power Drift = -0.4 dB
Area Scan (121x121x1): Measurement grid: $dx=20\text{mm}$, $dy=20\text{mm}$



With shielded ?? helmet

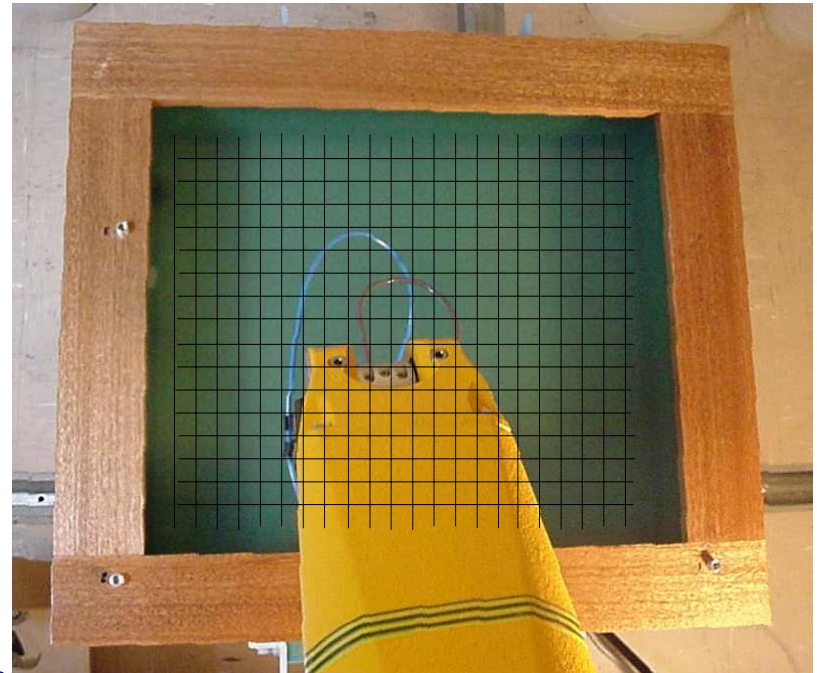
SAR Measurement Process

1. Power Reference Measurement
2. Surface Check
3. Area Scan
4. Zoom Scan
5. Power Drift Measurement

Area Scan Example

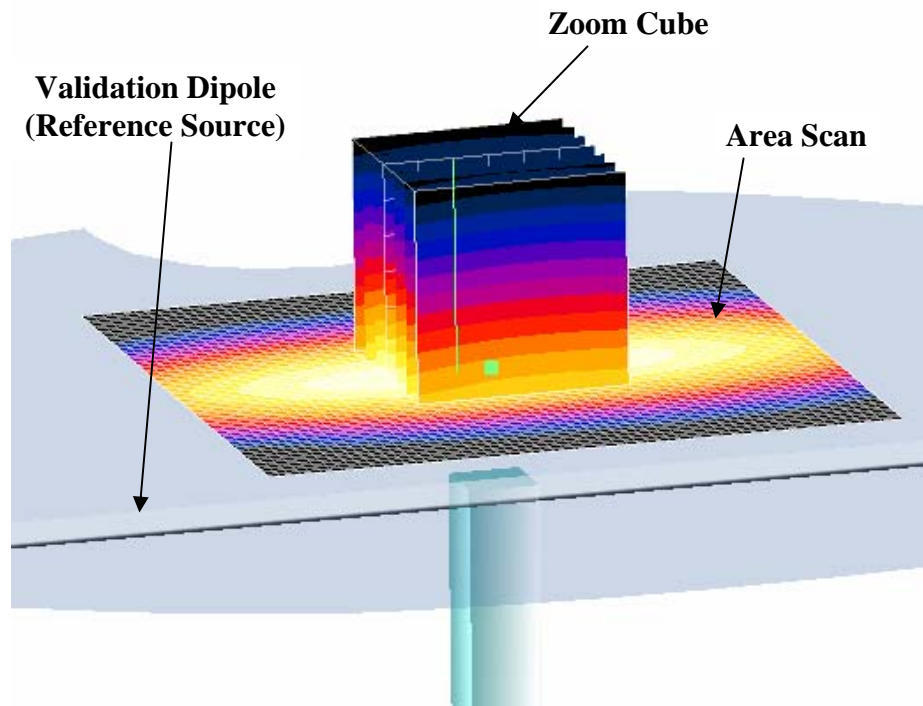


Flat Phantom



Example SAR Scan

- Example of SAR Area and Zoom scan setup using DASY4 system for 900MHz Validation.



Compliance Testing of WLAN Cards

- WLAN cards installed in laptop computers classified as “Portable Equipment” under general public/uncontrolled exposure category.
- Power level requirement set by ARPANSA standard are often exceeded and laptops can be used within 20cm of body.
- SAR testing usually required.

Wireless Technologies – Freq/Power Specifications

Technology	Frequency (GHz)	Output Power (mW)
Bluetooth	2.4	1/2.5/100
IEEE 802.11a	5	40-800
IEEE 802.11b	2.4	200
IEEE 802.11g	2.4	65
Ultrawideband	3-10	1

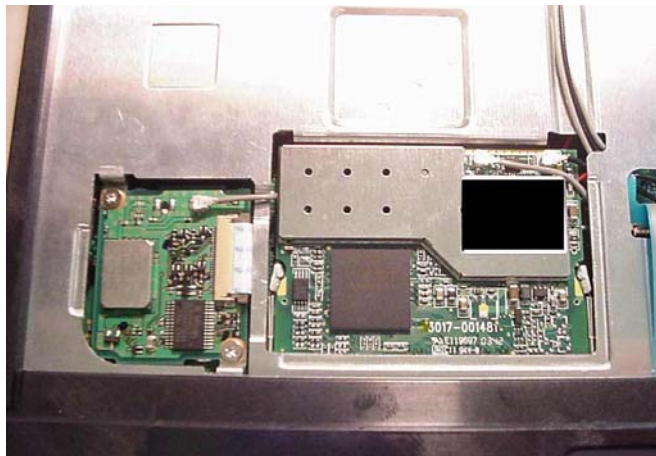
WLAN Modulation and Data Rates

WLAN Mode	Frequency Range (GHz)	Data Rates (Mbps)
802.11b - DSSS	2.412-2.462	1, 2, 5.5, 11
802.11g - OFDM		6, 9, 12, 18, 24, 36, 48, 56
802.11a – OFDM	5.150-5.250	6, 9, 12, 18, 24, 36, 48, 56

Compliance Testing of WLAN Cards (1)

- If a WLAN card incorporates all modes of operation then each mode must be assessed.
- Device modulation, power output and duty cycles must be taken into account.
- Intent is to test device conservatively.
- Compliance **testing** of multi-function devices becoming difficult for human exposure

Compliance Testing of WLAN Cards (2)



- Some laptop computers use three bands, 2450 MHz, 5200 MHz and 5800 MHz.
- Photo of WLAN card in typical laptop computer

Compliance Testing of WLAN Cards (3)

- Using a pre-approved transmitter does not guarantee compliance because it is not known how the original module was configured.
 - i.e Host changes or different antennas.
- WLAN card must be tested in the host device.

Compliance Testing Portable Equipment (1)

- Due to near field effects small changes in device positioning can lead to unexpected changes in energy absorption.
- Impact of device positioning must be considered.
- Current published standards; EN50361/IEEE p1528 precisely define the positioning relative to ear.

Compliance Testing Portable Equipment (2)

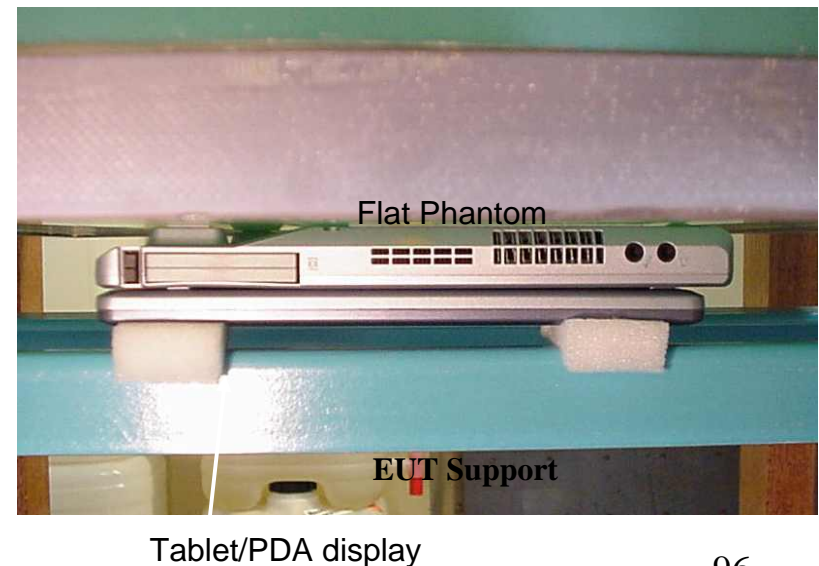
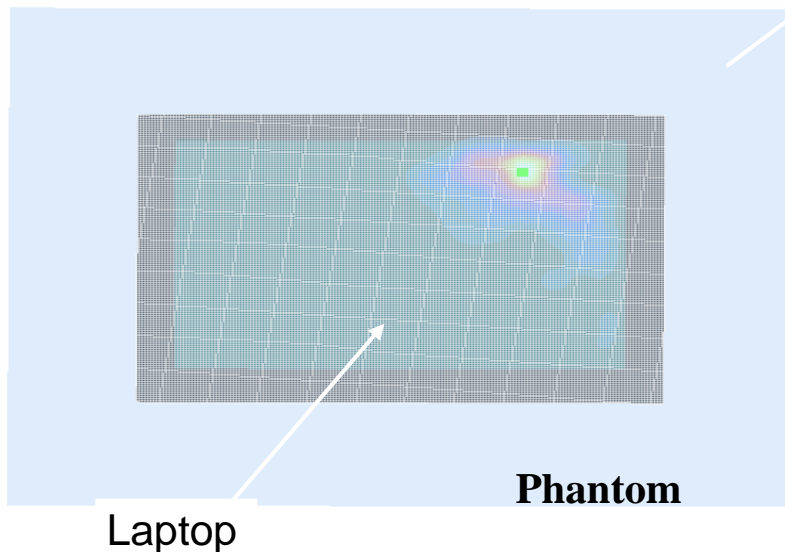
- FCC OET65C and ACA EMR Standard 2003 specify procedures for SAR measurements of devices used on the body.
- Procedures for body worn devices are intended for portable equipment supplied with headset jack.
 - i.e they can be used on the body with a hands free kit.
- For devices without a belt-clip a 1.5cm separation distance is typically applied.

Compliance Testing of Laptop and Tablet Portable Computers

- SAR test methods are constantly being updated.
- No defined procedures
- ACMA to provide FACT sheets
- FCC Guidelines and interpretations used

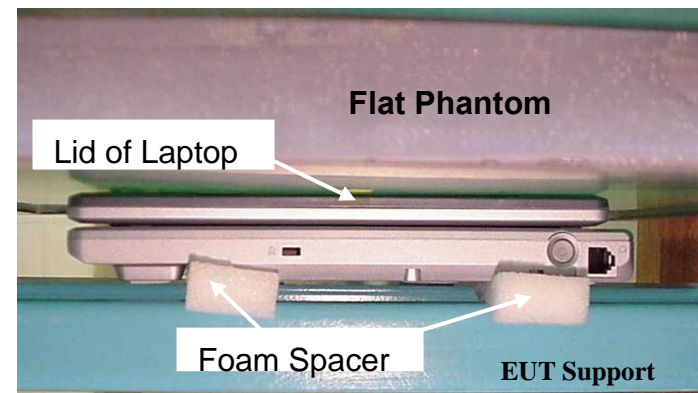
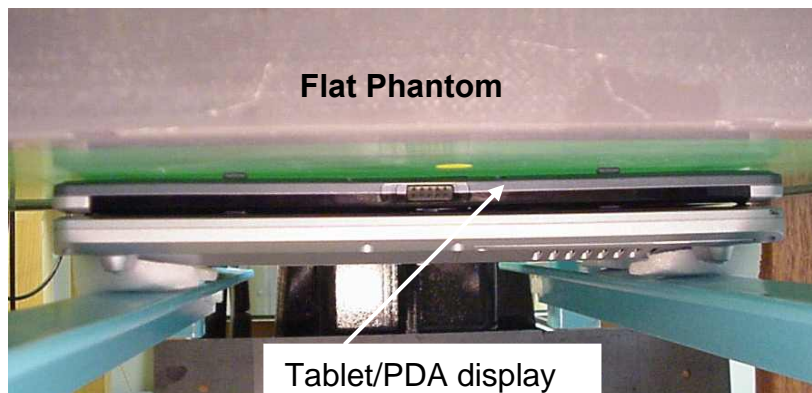
Lap Held Position (Tablet PC)

- Lap Held Position**: This position simulates a laptop/tablet PC used on a person's lap. This position provides a conservative estimate of the actual SAR a typical user would experience. The bottom side of the laptop is pressed against a flat phantom.



Arm Held Position (Tablet PC)

- **Arm-Held (Interactive Display) position:** If a tablet PC has display mounted antennas and an interactive screen display then this test configuration may be applicable. The face of the tablet screen is pressed against the flat phantom. This position is designed to evaluate forearm exposure. (limbs are exempt)



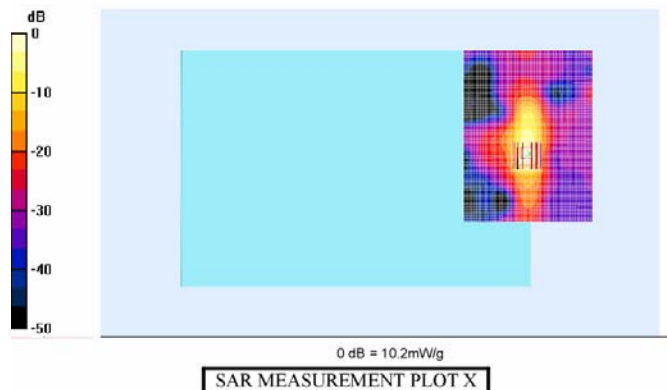
Case History (Arm-Held Position)

Test Date: XXXX

File Name: Arm-Held OFDM 5.77 GHz Bat# 4400MAh 16-10-03 TEST with Other Sample da4
DUT: XXXXX Tablet with WLAN; Type: XXXX 11abg Module; Serial: No.XX

* Communication System: OFDM 5770 MHz; Frequency: 5745 MHz; Duty Cycle: 1:1
* Medium: Body 5600 MHz; Medium parameters used (interpolated): $f = 5745$ MHz; $\sigma = 6.25$ mho/m; $\alpha = 44.3$; $\rho = 1000$ kg/m³
- Electronics: DAE3 Sn442; Probe: ES3DV3- SN3029; ConvF(1.8, 1.8, 1.8)
- Phantom: Flat Phantom 10.1; Serial: P 10.1; Phantom section: Flat 2.2 Section
Channel 149 Test 2/Area Scan (81x61x1): Measurement grid: dx=20mm, dy=20mm
Reference Value = 6.87 V/m
Power Drift = 0.2 dB
Maximum value of SAR = 7.44 mW/g

Channel 149 Test 2/Zoom Scan (7x7x8)/Cube 0: Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm
Peak SAR (extrapolated) = 37.8 W/kg
SAR(1 g) = 5.16 mW/g; SAR(10 g) = 0.970 mW/g
Reference Value = 6.87 V/m
Power Drift = 0.2 dB
Maximum value of SAR = 10.2 mW/g



Ambient Temperature
Liquid Temperature
Humidity

21.7 Degrees Celsius
20.1 Degrees Celsius
61 %

•Example of 5.8GHz SAR Compliance of Tablet PC.

•Highest Evaluated SAR

• 1g Cube = 5.16mW/g

• 10g Cube = 0.970mW/g

•Compliance Margins

•Exceeds FCC(USA) limit by over 3 times.

•50% of the ACA/EU limits

Test Date: XXXX

File Name: [Arm-Held OFDM 5.77 GHz Batt 4400MAh 16-10-03 TEST with Other Sample.da4](#)

DUT: XXXXX Tablet with WLAN; Type: XXXX 11abg Module; Serial: No.XX

* Communication System: OFDM 5770 MHz; Frequency: 5745 MHz; Duty Cycle: 1:1

* Medium: Body 5600 MHz; Medium parameters used (interpolated): $f = 5745$ MHz; $\sigma = 6.25$ mho/m; $\bar{\alpha}_r = 44.3$; $\bar{n} = 1000$ kg/m³

- Electronics: DAE3 Sn442; Probe: ES3DV3- SN3029; ConvF(1.8, 1.8, 1.8)

- Phantom: Flat Phantom 10.1; Serial: P 10.1; Phantom section: Flat 2.2 Section

Channel 149 Test 2/Area Scan (81x61x1): Measurement grid: dx=20mm, dy=20mm

Reference Value = 6.87 V/m

Power Drift = 0.2 dB

Maximum value of SAR = 7.44 mW/g

Channel 149 Test 2/Zoom Scan (7x7x8)/Cube 0: Measurement grid: dx=4.3mm, dy=4.3mm, dz=3mm

Peak SAR (extrapolated) = 37.8 W/kg

SAR(1 g) = 5.16 mW/g; SAR(10 g) = 0.970 mW/g

Reference Value = 6.87 V/m

Power Drift = 0.2 dB

Maximum value of SAR = 10.2 mW/g

•Example of 5.8GHz SAR Compliance of Tablet PC.

•Highest Evaluated SAR

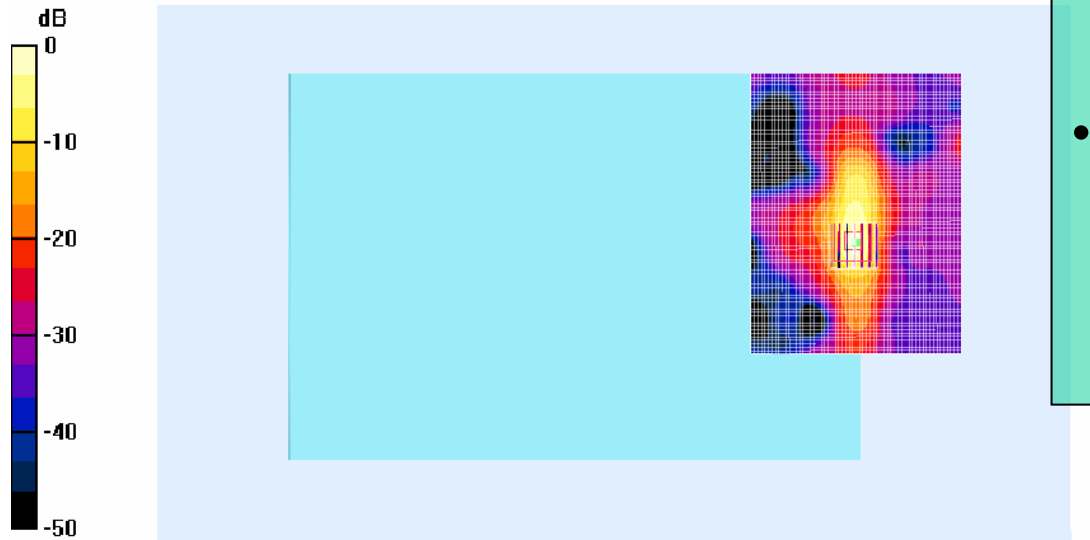
• **1g Cube = 5.16mW/g**

• **10g Cube = 0.970mW/g**

•Compliance Margins

•Exceeds FCC(USA) limit by over 3 times.

•50% of the ACA/EU limits



0 dB = 10.2mW/g

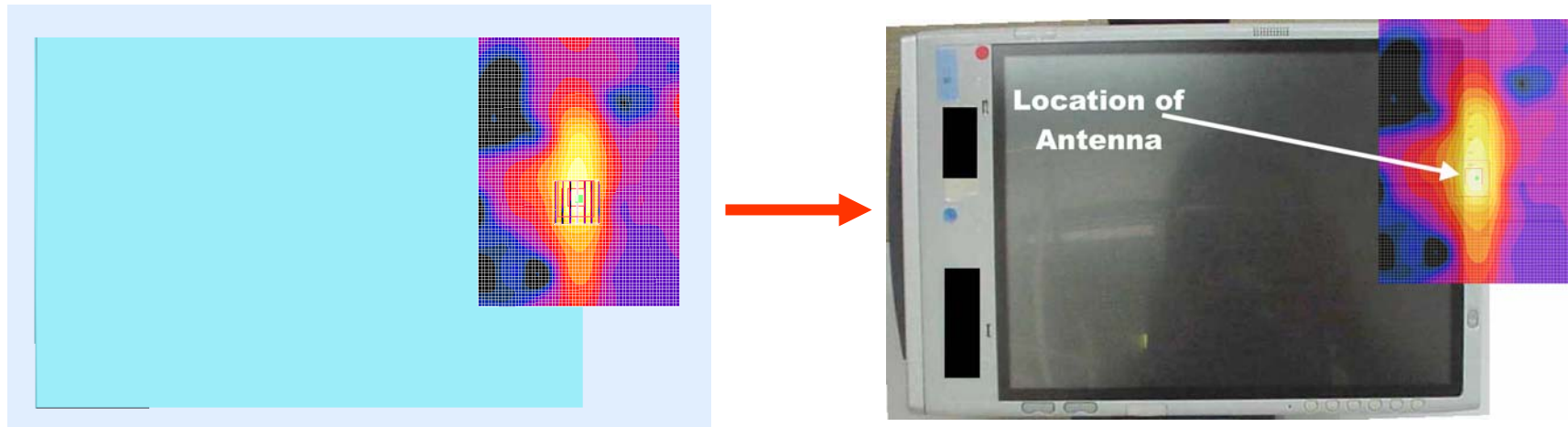
SAR MEASUREMENT PLOT X

Ambient Temperature
Liquid Temperature
Humidity

21.7 Degrees Celsius
20.1 Degrees Celsius
61 %

Case History (Arm-Held Position)

Illustration of the hotspot on the Tablet PC.



Edge Position



- **Edge Position**: Tablet PCs are held along the edges of the screen surround. Antennas that are located in these regions necessitate the need for SAR compliance. Hand exposure is not typically required but such positions are designed to evaluate forearm exposure.

Other Test Positions

- The “Back of Lid” position can account for occasional exposure to the arm or torso region.
- Not normally required to test for hand or wrists because of a higher SAR limit for the extremities.

Thank You

Chris Zombolas

chris@emctech.com.au

